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## BIOLOGICAL STUDIES IN MASSACHUSETTS.

## NO. 2.

BY GEORGE C. WHIPPLE.

## MICROSCOPICAL ORGANISMS.

The examination of nearly forty thousand samples of water in Massachusetts collected from water supplies differing in locality and character, and extending through all seasons for a long term of years serve to give us a good idea of the micro-organisms inhabiting the fresh waters of this region. But, in studying them it must be remembered that the examinations were made from a sanitary standpoint, and that from the manner in which the samples were collected they include only such forms as are found floating in the water: the littoral forms are not represented except as they have become detached and accidentally carried into circulation.

The following table gives the names of the genera thus far observed. They are arranged according to the usual system of classification, and each class is divided into groups, according to abundance and frequency of occurrence. The first group includes those genera which, in their season, are often found in large numbers; the second group includes those which are only occasionally found in large numbers; the third those which often occur in small numbers; the fourth those which are rarely observed. This division, while not wholly satisfactory, enables us to separate the important from the unimportant forms. As observations multiply, the list will doubtless be extended and many genera will be changed from one group to another. The names printed in heavy type indicate that the organisms so marked have been the cause of trouble in a water supply.

## DIATOMACEÆ.

*Commonly found in large numbers.* **Asterionella**, *Cyclotella*, **Melosira**, *Synedra*, **Tabellaria**.

*Occasionally found in large numbers.* *Diatoma*, *Fragilaria*, *Nitzschia*, **Stephanodiscus**.

*Commonly found in small numbers.* *Epithemia*, *Gomphonema*, *Navicula*, *Stauroneis*.

*Occasionally observed.* Achnanthes, Amphiprora, Amphora, Bacillaria, Cocconeis, Cocconema, Cymbella, Diademesmis, Encyonema, Eunotia, Grammatophora, Himantidium, Isthmia, **Meridion**, Odontidium, Orthosira, Pinnularia, Pleurosigma, Schizonema, Striatella, Surirella, Tetracyclus.

#### CHLOROPHYCEÆ.

*Commonly found in large numbers.* Chlorococcus, Protococcus, **Scenedesmus**.

*Occasionally found in large numbers.* Cœlastrum, Cosmarium, **Palmella**, **Pandorina**, Polyedrium, Raphidium, Staurostrum, **Volvox**.

*Commonly found in small numbers.* Closterium, Conferva, Desmidium, Euastrum, Eudorina, Gonium, Micrasterias, Ophiocytium, Pediastrum, Sphaerosoma, Staurogenia, Tetraspora, Ulothrix, Xanthidium.

*Occasionally observed.* Arthrodesmus, Bambusina, Botryococcus, Characium, Chaetophora, Cladophora, Dactylococcus, Dictyosphaerium, Dimorphococcus, Draparnaldia, Gloeocystis, Hyalotheca, Mesocarpus, Nephrocytium, Penium, Selenastrum, Sorastrum, Spirogyra, Stigeoclonium, Tetmemorus, Zygnema.

#### CYANOPHYCEÆ.

*Commonly found in large numbers.* **Anabaena**, **Clathrocystis**, **Coelosphaerum**, **Microcystis**.

*Occasionally found in large numbers.* **Aphanizomenon**, Chroococcus, **Oscillaria**.

*Commonly found in small numbers.* Aphanocapsa.

*Occasionally observed.* Gloeocapsa, Lyngbya, Merismopedia, Microcoleus, **Nostoc**, Rivularia, Sirosiphon, Tetrapedia.

#### FUNGI.

*Commonly found in large numbers.* **Crenothrix**.

*Occasionally found in large numbers.* Cladothrix.

*Commonly found in small numbers.* **Beggiatoa**, Leptothrix, Moulds.

*Occasionally observed.* Achlya, Leptomitosis, Saprolegnia, Sarcina, Spirillum.

#### RHIZOPODA.

*Commonly found in small numbers.* Actinophrys, Amoeba.

*Occasionally observed.* Arcella, Cyphodera, Diffugia, Euglypha.

#### INFUSORIA.

*Commonly found in large numbers.* **Cryptomonas**, **Dinobryon**, **Peridinium**, **Synura**, **Uroglena**.

*Occasionally found in large numbers.* Bursaria, Chloromonas, **Glenodinium, Mallomonas, Raphidomonas.**

*Commonly found in small numbers.* Anthophysa, Ceratium, Cercomonas, Codonella, Epistylis, Monas, Tintinnus, Trachelomonas, Vorticella.

*Occasionally observed.* Acineta, Chlamydomonas, Coleps, Colpidium, Euchelys, Euglena, Euplotes, Glaucoma, Halteria, Heteronema, Nassula, Paramaecium, Phacus, Pleuronema, Raphidodendron, Stentor, Syncrypta, Trichodina, Uvella, Zoothamnium.

#### ROTIFERA.

*Commonly found in small numbers.* Anuraea, Conochilus, Polyarthra, Rotifera, Synchaeta.

*Occasionally observed.* Asplanchna, Colurus, Eosphora, Floscularia, Lacinularia, Mastigocerca, Microcodon, Monocerca, Monostyla, Noteus, Sacculus, Triarthra.

#### CRUSTACEA.

*Commonly found in small numbers.* Bosmina, Cyclops, Daphnia.

*Occasionally observed.* Alona, Cypris, Diaptomus, Sida.

#### MISCELLANEOUS.

*Occasionally observed.* Acarina, Anguillula, Batrachospermum, Chaetonotus, Gordius, Hydra, Macrobrotus, Meyenia, Nais, Spongilla; besides spores, ova, insect scales, pollen grains, vegetable fibres and tissue, yeast cells, starch grains, etc.

An examination of the following table, a numerical summary of the preceding list, brings out some interesting facts:—

It will be observed that 186 genera have been reported, 108 plants and 78 animals. Of these only 18 are commonly found in large numbers, 13 plants and 5 animals. Twenty-one more are occasionally found in large numbers, 16 plants and 5 animals. Forty-one genera are frequently seen in small numbers, while 106 genera, or more than one-half of all are seen occasionally, some of them but rarely. The most important classes are the Diatomaceæ, Chlorophyceæ, Cyanophyceæ and Infusoria, as shown by the large number of genera and by their greater abundance. Furthermore, these classes include all but one of the 23 troublesome genera that have been found in large numbers. Eleven genera may be said to be very troublesome, because of their wide distribution, the frequency of their occur-

TABLE NO. 1.

Classification.	Number of Genera.				Total.
	Commonly found in large numbers.	Occasionally found in large numbers.	Commonly found in small numbers.	Occasionally observed.	
Diatomaceæ.....	5	4	4	22	35
Chlorophyceæ.....	3	8	14	21	46
Cyanophyceæ.....	4	3	1	8	16
Fungi.....	1	1	3	5	10
Rhizopoda.....	0	0	2	4	6
Infusoria.....	5	5	9	20	39
Rotifera.....	0	0	5	12	17
Crustacea.....	0	0	3	4	7
Miscellaneous.....	0	0	0	10	10
Total.....	18	21	41	106	186

rence, and their unpleasant effects. They are *Asterionella*, *Anabaena*, *Clathrocystis*, *Coelosphaerium*, *Aphanizomenon*, *Oscillaria*, *Dinobryon*, *Peridinium*, *Synura*, *Uroglena* and *Glenodinium*. This list seems like a short one when one considers the annoyance that the micro-organisms have caused in the various water supplies of the State.

The following tables, compiled from the examinations of the State Board of Health, serve to give one an idea of the distribution of the various classes of organisms in ground waters and surface waters. In most cases the numbers given are the averages of monthly examinations extending over one or more years. They were selected with a view to showing the greatest range in the number of organisms in the classes of water tabulated, and they illustrate in a striking manner the comparative absence of organisms (except Fungi) in springs, wells and filter galleries: the presence of a variety of organisms in small numbers in rivers, and the abundance of microscopic life in the more quiet waters of ponds and artificial reservoirs. It is only in waters of the latter class that the microscopical organisms occasion much trouble by their excessive growth, and hereafter they alone will receive our consideration.

TABLE No. 2.  
MICROSCOPICAL ORGANISMS IN GROUND WATERS.  
(NUMBER PER C. C.)

No.	Locality.	Time.	Diatomaceae.	Chlorophyceae.	Cyano-phyceae.	Fungi.	Rhizopoda.	Infusoria.	Rotifera.	Total Organisms.	Zoogloea (Units).
SPRING WATERS.											
I	Spring in Westport.....	Apr. 21, 1894	455	0	3	0	0	0	1	459	0
II	Aqua Rex Spring, Mills.....	Aug. 27, 1894	1	180	0	0	0	0	0	181	0
III	Craig Spring, West Springfield.....	May 16, 1893	21	0	0	0	0	0	0	21	16
IV	Spring in Ipswich.....	July 27, 1892	12	0	0	0	0	0	0	12	0
V	Spring in Pepperell.....	Nov. 26, 1894	1	1	0	2	0	0	0	4	4
VI	Massasoit Spring, West Springfield.....	May 16, 1893	2	0	0	0	0	0	0	2	0
VII	Spring in Ware.....	July 17, 1893	0	0	0	0	0	1	0	1	0
VIII	Spring in Medfield.....	Aug. 31, 1894	0	0	0	0	0	0	0	0	0
IX	Spring in Pittsfield.....	Aug. 27, 1894	0	0	0	0	0	0	0	0	0
X	Cold Spring, Plymouth.....	July-Dec., 1894	0	0	0	0	0	0	0	0	0
WELL WATERS.											
I	Tubular Well, Provincetown.....	1894	0	0	0	3130	0	0	0	3130	50
II	Tubular Wells, Revre.....	1894	1	0	0	281	0	0	0	282	—
III	Large Collecting Well, Marblehead.....	1894	0	0	0	173	0	0	0	173	8
IV	Tubular Wells, Hyde Park.....	1893-4	2	0	0	68	0	pr.	0	70	18
V	Tubular Wells, Malden.....	1891-3	5	0	1	1	pr.	1	0	8	7
VI	Tubular Wells, Lowell.....	1893	0	2	0	0	0	0	0	2	—
VII	Tubular Wells, Melrose.....	1894	0	0	0	1	0	0	0	1	—
VIII	Tubular Wells, Bradford.....	1893	0	0	0	1	0	pr.	0	1	547
IX	Well, Needham.....	1894	0	0	0	0	0	0	0	0	0
X	Well at Fitzwilliam, N. H.....	1893	0	0	0	0	0	0	0	0	0
FILTER GALLERIES.											
I	Filter Gallery at Reading.....	1891-4	3	0	0	3606	0	2	0	3511	726
II	Filter Gallery at Wayland.....	1891	15	4	1	1706	0	3	0	1729	71
III	Filter Gallery at Whitman.....	1891	1	0	0	137	0	0	0	138	41
IV	Filter Gallery at Watertown.....	1892	pr.	0	0	217	0	0	0	217	72
V	Filter Gallery at Framingham.....	1891	1	0	0	137	0	0	0	138	41
VI	Filter Gallery at Braintree.....	1894	0	0	0	34	0	2	0	36	94
VII	Filter Gallery at Woburn.....	1891	2	0	0	0	0	0	0	2	1
VIII	Filter Basin at Taunton.....	1891-4	86	2	4	24	0	48	1	165	14
IX	Filter Basin at Newton.....	1892-4	2	1	0	15	0	pr.	0	18	13
X	Filter Basin at Waltham.....	1892	17	0	0	0	0	pr.	0	17	4

TABLE No. 3.  
MICROSCOPICAL ORGANISMS IN SURFACE WATERS.  
(NUMBER PER C. C.)

No.	Locality.	Time.	Diatomaceae.	Chloro-phyceae.	Cyano-phyceae.	Fungi.	Rhizopoda.	Infsoria.	Rotifera.	Total Organisms.	Zoogloea (Units).
RIVERS.											
I	Stony Brook, Inflow to Basin 3.	1891-2	77	23	43	38	1	9	0	191	97
II	Mill River at Taunton.	July-Sept. 1893	3	25	1	165	1	4	pr.	199	676
III	Merrimac River at Lawrence.	1891-4	66	21	2	13	pr.	4	pr.	106	156
IV	Ipswich River.	1892	12	1	0	87	0	5	0	105	31
V	Blackstone River at Uxbridge.	1892	17	6	0	3	0	74	pr.	100	384
VI	Sudbury River, Inflow to Basin 2.	1891-2	45	16	2	32	pr.	1	pr.	98	128
VII	Cold Spring Brook, Inflow to Basin 4.	1891	54	pr	2	12	0	1	0	77	39
VIII	Nashua River, North Branch.	1893	13	4	0	42	0	6	0	67	810
IX	Taunton River.	1891-3	17	1	2	13	0	2	0	35	58
X	Lynde Brook, Worcester.	1891	17	4	3	2	0	1	0	27	68
NATURAL PONDS.											
I	Mystic Lake.	1891-4	1917	199	pr.	18	pr.	172	pr.	2306	128
II	Jamaica Pond.	1891-4	1110	103	137	1	1	12	1	1765	174
III	Horn Pond, Woburn.	Jan.-Aug. 1891	911	302	218	1	1	167	2	1602	65
IV	Fresh Pond, Cambridge.	1891-4	967	95	83	9	1	4	pr.	1159	127
V	Wenham Lake, Salem.	1891-4	897	38	32	2	pr.	32	pr.	999	52
VI	Buckmaster Pond, Norwood.	1891-4	184	83	9	2	1	665	pr.	944	30
VII	Lake Cochituate.	1891-4	579	33	58	6	2	15	pr.	693	66
VIII	Spot Pond, Malden.	1891-4	171	85	19	1	1	19	pr.	296	93
IX	Lake Williams, Marlboro.	1891	170	17	66	1	0	14	0	268	67
X	Gates Pond, Hudson.	1891-4	110	37	27	1	1	66	pr.	242	38
ARTIFICIAL RESERVOIRS.											
I	Haynes Reservoir, Leominster.	1891	3193	0	0	1	0	19	1	3214	155
II	Walden Pond, Lynn.	1891-4	254	238	604	8	pr.	397	1	1502	64
III	North Reservoir, Winchester.	1891-4	1337	35	72	1	1	149	pr.	1896	71
IV	Ludlow Reservoir, Springfield.	1891-4	504	260	96	5	1	96	2	964	103
V	Scott Reservoir, Fitchburg.	1892	691	146	10	2	4	92	2	947	42
VI	Holden Reservoir, Worcester.	1891-4	646	24	6	1	pr.	29	1	707	76
VII	Basin 3, Boston.	1891-4	270	55	23	1	1	12	pr.	362	122
VIII	Basin 2, Boston.	1891-4	99	32	47	5	pr.	4	pr.	187	125
IX	Basin 4, Boston.	1891-4	80	31	3	1	0	5	0	120	43
X	Basin 6, Boston.	1894	55	5	0	0	1	31	2	94	20